

The Brown Marmorated Stink Bug and its Biological Control – Quo vadis?

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Abstract

*The brown marmorated stink bug, *Halyomorpha halys*, is a globally important, invasive pest insect from Central Asia. It can cause severe economic damages in fruit and vegetable crops, e.g. apple, pear, peach, hazelnut, cucumber and pepper. In Germany, it was first recorded in 2011 and has since spread to all federal states, benefiting from global warming and international trade and tourism. Pest management strategies such as insecticide treatments, exclusion nets or trapping have no long-term impact on decreasing population densities on an area-wide level. Biological control is a sustainable management approach and an important element in the long-term control of the brown marmorated stink bug. Studies have shown that native natural enemies, i.e. egg parasitoids, are not sufficiently adapted to this invasive pest to keep it below economic thresholds. The scelionid egg parasitoid, *Trissolcus japonicus* (the „samurai wasp“) is an important natural enemy of *H. halys* in Asia. Adventive populations of *T. japonicus* have since been detected in many areas invaded by the brown marmorated stink bug. In 2020, the samurai wasp was first recorded in Baden-Wuerttemberg in Germany and has since become established in three additional states. Here, we will present the current state of the distribution of *H. halys* and *Trissolcus japonicus* and we will discuss biological control options against *H. halys* in Germany.*

Keywords: *Halyomorpha halys*, *Trissolcus japonicus*, biological control.

Introduction

The brown marmorated stink bug, *Halyomorpha halys* Stål 1855 (Heteroptera: Pentatomidae) is an invasive pest in horticultural crops as well as urban settings worldwide. Originally from Asia, it has had significant ecological and economic impacts in the invaded areas. It is notoriously difficult to control due to its high mobility, broad host plant range, and high resilience to insecticides (Leskey & Nielsen, 2018). Biological control against *H. halys* has become an important management option for growers. In particular, biological control by natural enemies can provide sustainable long-term control of this invasive pest and can avoid or reduce the application of insecticides. Egg parasitoids in the family Scelionidae (Hymenoptera) are important biological control agents of stink bugs in general. In the new areas of distribution it has been shown, though, that biological control by native natural enemies is not sufficient to control *H. halys*, as parasitism and predation rates have been low (Rice *et al.*, 2014; Haye *et al.*, 2015; Moraglio *et al.*, 2020). Throughout its countries of origin, *H. halys* is primarily parasitized by several egg parasitoid species in the genus *Trissolcus* Ashmead (Talamas *et al.*, 2019). *Trissolcus japonicus* (Ashmead) has been identified as the dominant natural enemy of the brown marmorated stink bug with parasitism rates of up to 90 % (Yang *et al.*, 2009; Talamas *et al.*, 2013). The distribution range of *T. japonicus* widely overlaps with that of *H. halys* in the native ranges. And with *H. halys*' invasive trip around the world, *T. japonicus* has been following in its footsteps. Adventive populations of *T. japonicus* have been found, e.g. in North America, Italy, Switzerland, and Germany (Talamas *et al.*, 2015; Stahl *et al.*, 2019; Dieckhoff *et al.*, 2021; Zapponi *et al.*, 2021). In Germany, *T. japonicus* was first discovered in 2020 in Baden-Wuerttemberg. A

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monitoring of *H. halys* and its natural enemies in various agricultural and urban habitats was conducted to assess the distribution of both pest and beneficial insects as well as the state of establishment of *T. japonicus* in Germany.

Material and Methods

Monitoring efforts focusing on *H. halys* and potential natural enemies were conducted between 2016 and 2023. Data were collected on the spread of *H. halys* in Germany as well as the presence and impact of natural enemies of *H. halys*. This study was also supported by data collected by plant protection offices across Germany as well as the citizen scientist community of iNaturalist (iNaturalist, 2023). Data provided via iNaturalist were verified by the authors prior to being included in the analyses. Insect samples were processed at the Agricultural Research Center (LTZ) Augustenberg and parasitoids were identified both morphologically and molecularly. For *Trissolcus* species the keys provided by Talamas *et al.* (2017) and Tortorici *et al.* (2019) were used. Molecular analyses were performed following the protocol outlined in Dieckhoff *et al.* (2021).

Results and Discussion

Since *H. halys* first discovery in 2011, this pest has spread rapidly throughout Germany and has been found in every federal state so far. The monitoring and sampling efforts showed that native natural enemies have had a low impact on *H. halys* populations in Germany. This is conclusive with what has been found in North America and other European countries and confirms that *H. halys* initially successfully evaded natural enemy pressure in the newly invaded countries (Haye *et al.*, 2015, Moraglio *et al.*, 2020). In 2020, adventive populations of *Trissolcus japonicus* were found at two separate locations in Baden-Wuerttemberg. This egg parasitoid was presumably introduced unintentionally from its native range along with its host *H. halys*. *T. japonicus* is an oligophagous egg parasitoid following the distribution of its primary host *H. halys* (Haye *et al.* 2023). Host range as well as parasitism rates of *H. halys* egg masses correspond to those reported from *T. japonicus*' native Asian range as well as from other European countries where adventive populations of *T. japonicus* have been found. This survey has shown that *T. japonicus* has since spread autonomously over an area of approximately 400 km covering a total of four federal states. Recoveries of *T. japonicus* at the same sites in consecutive years have confirmed that this natural enemy of *H. halys* has become established in Germany. At those locations, both parasitized *H. halys* egg masses as well as adult *T. japonicus* individuals were found, thus verifying that *T. japonicus* is able to successfully reproduce and overwinter under the local climate conditions.

Trissolcus japonicus is a prime candidate for a classical biological control program against *H. halys*. In Italy, a release permit was approved by the relevant federal authorities in 2019. The subsequent field reports have been very promising showing a quick establishment of *T. japonicus* in the release areas as well as good parasitism of the target host, *H. halys* (Zapponi *et al.*, 2021). In Germany, a release of *T. japonicus* is not permitted by the responsible federal agency at this point in time due to concerns regarding non-target impacts on native stink bug species. Several studies, however, have shown that non-target impacts by *T. japonicus* on native species are negligible and may only affect a few species sharing the same habitat as *H. halys* (Haye *et al.*, 2023). Therefore, the legal framework in Germany should be amended in order to enable future classical biological control programs against invasive pests, such as *H. halys*, based on an appropriate risk-benefit assessment.

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References

- Dieckhoff, C., Wenz, S., Renninger, M., Reißig, A., Rauleder, H., Zebitz, C.P.W., Reetz, J., Zimmermann, O. (2021). Add Germany to the list—Adventive population of *Trissolcus japonicus* (Ashmead) (Hymenoptera: Scelionidae) emerges in Germany. *Insects* 12(5): 414. DOI: 10.3390/insects12050414
- Haye, T., Fischer, S., Zhang, J., Garipey, T. (2015). Can native egg parasitoids adopt the invasive brown marmorated stink bug, *Halyomorpha halys* (Heteroptera: Pentatomidae), in Europe? *Journal of Pest Science* 88(4): 693–705. DOI: 10.1007/s10340-015-0671-1
- Haye, T., Moraglio, S.T., Tortorici, F., Marazzi, C., Garipey, T.D., Tavella, L. (2023). Does the fundamental host range of *Trissolcus japonicus* match its realized host range in Europe? *Journal of Pest Science* <https://doi.org/10.1007/s10340-023-01638-0>
- iNaturalist. Available from <https://www.inaturalist.org>. Accessed 12 December 2023.
- Leskey, T. C., Nielsen, A.L. (2018). Impact of the invasive brown marmorated stink bug in North America and Europe: History, biology, ecology, and management. *Annual Review of Entomology* 63(1): 599–618. DOI: 10.1146/annurev-ento-020117-043226
- Moraglio, S.T., Tortorici, F., Pansa, M.G., Castelli, G., Pontini, M., Scovero, S., Visentin, S., Tavella, L. (2020). A 3-year survey on parasitism of *Halyomorpha halys* by egg parasitoids in northern Italy. *Journal of Pest Science* 93(1): 183–194. DOI: 10.1007/s10340-019-01136-2
- Rice, K.B., Bergh, C.J., Bergmann, E.J., Biddinger, D.J., Dieckhoff, C., Dively, G., Fraser, H., Garipey, T., Hamilton, G., Haye, T., Herbert, A., Hoelmer, K.A., Hooks, C.R., Jones, A., Krawczyk, G., Kuhar, T., Martinson, H., Mitchell, W., Nielsen, A.L., Pfeiffer, D.G., Raupp, M.J., Rodriguez-Saona, C., Shearer, P., Shrewsbury, P., Venugopal, P.D., Whalen, J., Wiman, N.G., Leskey, T.C., Tooker, J.F. (2014). Biology, ecology, and management of brown marmorated stink bug (Hemiptera: Pentatomidae). *Journal of Integrated Pest Management* 5(3): 1–13, DOI: 10.1603/IPM14002
- Stahl, J., Tortorici, F., Pontini, M., Bon, M.-C., Hoelmer, K.A., Marazzi, C., Tavella, L., Haye, T. (2019). First discovery of adventive populations of *Trissolcus japonicus* in Europe. *Journal of Pest Science* 92(2): 371–379. DOI: 10.1007/s10340-018-1061-2
- Talamas, E.J., Buffington, M., Hoelmer, K.A. (2013). New synonymy of *Trissolcus halyomorphae* Yang. *Journal of Hymenoptera Research* 33: 113–117. DOI: 10.3897/jhr.33.5627
- Talamas, E.J.; Buffington, M.L.; Hoelmer, K.A. (2017). Revision of Palearctic *Trissolcus* Ashmead (Hymenoptera, Scelionidae). *Journal of Hymenoptera Research* 56: 79–261.
- Talamas, E.J., Bon, M.-C., Hoelmer, K.A., Buffington, M.L. (2019). Molecular phylogeny of *Trissolcus* wasps (Hymenoptera, Scelionidae) associated with *Halyomorpha halys* (Hemiptera, Pentatomidae). *Journal of Hymenoptera Research* 73: 201–217. DOI: 10.3897/jhr.73.39563
- Talamas, E.J., Herlihy, M.V., Dieckhoff, C., Hoelmer, K.A., Buffington, M., Bon, M.-C., Weber, D.C. (2015). *Trissolcus japonicus* (Ashmead) (Hymenoptera, Scelionidae) emerges in North America. *Journal of Hymenoptera Research* 43: 119–128. DOI: 10.3897/JHR.43.4661
- Tortorici, F.; Talamas, E.J.; Moraglio, S.T.; Pansa, M.G.; Asadi-Farfar, M.; Tavella, L.; Caleca, V. A Morphological, biological and molecular approach reveals four cryptic species of *Trissolcus* Ashmead (Hymenoptera, Scelionidae), egg parasitoids of Pentatomidae (Hemiptera). *Journal of Hymenoptera Research* 73: 153–200.

- Yang, Z.-Q., Yao, Y.-X., Qiu, L.-F., Li, Z.-X. (2009). A New Species of *Trissolcus* (Hymenoptera: Scelionidae) parasitizing eggs of *Halyomorpha halys* (Heteroptera: Pentatomidae) in China with comments on its biology. *Annals of the Entomological Society of America* 102(1): 39–47. DOI: 10.1603/008.102.0104
- Zapponi, L., Tortorici, F., Anfora, G., Bardella, S., Bariselli, M., Benvenuto, L., Bernardinelli, I., Butturini, A., Caruso, S., Colla, R., Costi, E., Culatti, P., Di Bella, E., Falagiarda, M., Giovannini, L., Haye, T., Maistrello, L., Malossini, G., Marazzi, C., Marianelli, L., Mele, A., Michelon, L., Moraglio, S.T., Pozzebon, A., Preti, M., Salvetti, M., Scaccini, D., Schmidt, S., Szalatnay, D., Roversi, P.F., Tavella, L., Tommasini, M.G., Vaccari, G., Zandigiacomo, P., Sabbatini-Peverieri, G. (2021). Assessing the distribution of exotic egg parasitoids of *Halyomorpha halys* in Europe with a large-scale monitoring program. *Insects* 12(4): 316. DOI: 10.3390/insects12040316

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